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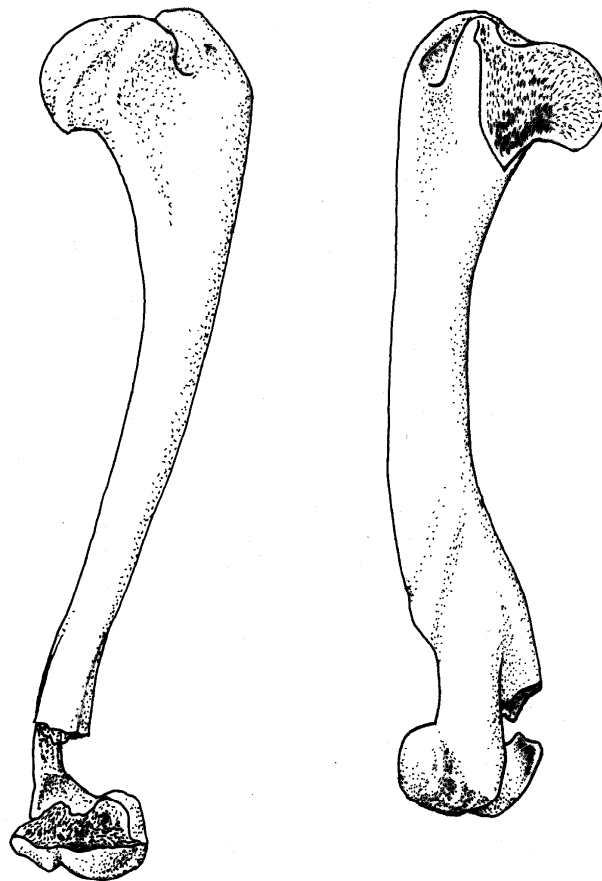
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# 6. Understanding past human-animal relationships through the analysis of fractures: a case study from a Roman site in The Netherlands

Maaïke Groot

## Abstract

*In studying fractures in archaeology, we should focus on what they can tell us about human-animal relationships. It is important to show other (zoo-) archaeologists that palaeopathology can be a valuable tool in answering (zoo-) archaeological questions. In this paper, a short summary of fracture types, healing, and complications is given and the problems and possibilities of studying fractures in palaeopathology are discussed. Nineteen fractures from a Roman-period site in The Netherlands are then presented. Fracture prevalence rates for this site are discussed and compared with currently published data. Possible explanations for the high fracture rate in dogs are discussed, including maltreatment by humans and work-related injuries.*

## Introduction

Fractures are one of the most common types of pathology seen in archaeological assemblages of animal bones (Ortner 2003, 119); they are also one of the easiest to recognise and diagnose. Unless they are very well-healed, fractures will be recognisable to all but the most inexperienced zooarchaeologist. This makes it less likely that this type of pathology will be overlooked, and this means that, taphonomic factors aside, the number of fractures for different samples can be regarded as broadly representative of the prevalence of fractures within a living population; although the numbers of well-healed green-stick and stress fractures are likely to be underestimated (see below).

Fractures in animal bones have not received the attention they deserve and there are few publications that deal specifically with their occurrence (Gal this volume; Teegen 2005; Udrescu and Van Neer 2005). Because of the scarcity of publications, this study largely makes use of palaeopathological literature on human fractures. However, while the biological responses to fractures, such as the healing process and subsequent complications, will be similar for all mammals, it is recognised that their frequency and distribution is not comparable because of the differences in anatomical position and activities between humans and other mammals.

This paper will detail the animal bone fractures recorded from an archaeological site in The Netherlands: Tiel-Passewaaij (Fig. 6.1). The site dates to the Roman period and is situated within the borders of the Roman Empire. This paper will be concerned with the animal bones from two rural settlements in this location. No fractures were found in wild animals; therefore only domestic mammals are discussed. The total number of identified domestic mammal bones from these two settlements was 13,358 (including complete or partial skeletons).

Before examining the fractures from Tiel-Passewaaij, a

short summary of the different types of fracture, the process of healing, the complications that may arise during healing, and the problems encountered when studying animal bone fractures are discussed.



**Figure 6.1:** map of The Netherlands indicating the location of Tiel-Passewaaij.

## Types of fractures

A fracture can be defined as “an incomplete or complete break in the continuity of a bone” (Lovell 1997, 141) and is usually the result of abnormal stress applied to a bone (Ortner 2003, 120). We can distinguish three basic kinds of fracture:

1. Acute fractures – resulting from either direct or indirect trauma;
2. Stress or fatigue fractures – caused by repetitive stress. The fracture line is usually perpendicular to the longitudinal axis of the bone and may resemble a transverse fracture. Stress fractures are usually not displaced and are often not visible on x-rays prior to callus formation (Lovell 1997, 144). Stress fractures often heal very well, and can be difficult to detect in archaeological samples (Ortner 2003, 125);
3. Pathological fractures – these occur when the bone structure has been affected by a local pathological process. Because the structure of the bone has become weaker, the bone is no longer able to withstand relatively normal biomechanical stress (Ortner 2003, 125). Underlying pathological conditions can be congenital, metabolic or infectious. Neoplasms can also weaken bone (Ortner 2003, 125). Osteoporosis commonly results in pathological fractures.

In acute fractures, a further distinction can be made between fractures caused by direct or indirect trauma. In direct trauma, there are three different fracture types. In a transverse fracture, the line of the break is perpendicular to the longitudinal axis of the bone and is caused by a relatively small force directed at a small area (Lovell 1997, 141). Penetrating fractures result from a large force delivered to a small area (Lovell 1997, 141) and are caused by sharp objects. In archaeological cases, it is very difficult to identify the object that caused the wound, unless the point has broken off and remained in the bone, although the absence of healing can show that the wound was severe enough to result in death. Finally, crush fractures occur in cancellous bone and result from direct force, which causes the bone to collapse (Lovell 1997, 142). Crush fractures can be caused by blunt trauma and are often found on the skull.

When a fracture occurs away from the location where the force was applied it is called indirect trauma (Lovell 1997, 142). Types of fractures resulting from indirect trauma are oblique, spiral, greenstick, impacted and avulsion fractures. In an oblique fracture, the fracture line angles across the longitudinal axis (Lovell 1997, 142). This type of fracture is caused by a combined angulated/rotated force. In a spiral fracture, the fracture line spirals around the longitudinal axis. This type of fracture is caused by rotational and downward loading stress on the longitudinal axis. In well-healed fractures, it is difficult to see the difference between oblique and spiral fractures (Lovell 1997, 142-3). Greenstick fractures are incomplete fractures and are common in non-adult bones, where the bone bends rather than breaks. Usually it is the convex side of the bone that breaks (Lovell 1997, 143). In an impacted fracture, the bone ends are forced into each other. In humans, this is often found in the proximal humerus as a result from a fall onto an outstretched hand (Lovell 1997, 143). An avulsion fracture occurs when a ligament or tendon is pulled away from its attachment to the bone and tears off a fragment of bone. Finally, a comminuted fracture occurs where the bone breaks into more than two fragments and this can be caused by either direct or indirect trauma (Lovell 1997,

143).

Apart from the types of fractures described above, we must also distinguish between open and closed fractures. A fracture where soft tissue and skin has also been injured, and where the fracture is exposed, is called an open or compound fracture. Open fractures are susceptible to infection.

## Healing

The healing of fractures generally follows a predictable sequence of events. First, a haematoma is formed at the site of the fracture. The haematoma is formed by blood flowing from vessels that have been torn by the fracture. The ends of the fractured bone die because of a lack of blood supply (Lovell 1997, 145, table 3). In the next stage, the haematoma is organised into a fibrous mass, uniting the fractured bone after about three weeks (Aufderheide and Rodriguez-Martin 1998, 21). In the third stage, primary bony callus forms within the fibrous mass (Ortner 2003, 126). The primary callus subsequently remodels into secondary callus and the woven bone transforms into lamellar bone. This provides a stronger union between the ends of the bone (Ortner 2003, 127). The final stage of healing is the remodelling of the bone to its original form (Lovell 1997, 145, table 3). The callus is reduced to the minimal amount that is necessary for biomechanical strength (Ortner 2003, 127-8).

Healing time is variable, but will be faster in cancellous bone than in cortical bone, and occurs twice as fast in children than in adults (Ortner 2003, 126, 128). Factors influencing the speed of healing are age, blood supply, fracture type, and skeletal element. Spiral and oblique fractures heal faster than transverse fractures (Lovell 1997, 145). Good health and nutritional state are extremely important if the healing is to be successful. Immobilisation of the injured bone aids healing, while mobility stimulates fibrous callus formation, which takes longer to heal. Infection or any other pathological process will delay healing (Aufderheide and Rodriguez-Martin 1998, 21). At least two weeks of healing are needed before the callus can be recognised in dry bones (Aufderheide and Rodriguez-Martin 1998, 23).

## Complications

Complications of acute fractures depend on the location and severity. Many complications can occur, although only the more common ones will be outlined here. First, inadequate fusion of the fracture can occur. Non-union can be diagnosed by rounded ends of the fractured bone, and a sealed marrow cavity; radio-logically, the bone ends show sclerosis. Non-union can result from infection, poor blood supply, deficiencies of vitamins or calcium, or lack of immobilisation of the fractured bone. If the fractured ends of the bone continue to move against each other, a false joint or pseudo-arthritis may form (Lovell 1997, 147). Malunion occurs when a fracture heals with

deformity, such as shortening or angulation. Misalignment and shortening of bones can cause other problems, such as osteoarthritis. A second complication is infection, although this is more likely to occur in an open fracture. Post-traumatic infection can be localised to the site of the fracture, but it can also spread through the bloodstream to other parts of the body (Lovell 1997, 146). Infection can show up as periostitis or osteomyelitis. Nerve damage is a further complication that can occur and can result in muscle atrophy; if the nerve loss is permanent, the bones will show disuse atrophy. If nerve damage involves loss of sensation at the fracture site, the individual will be less likely to immobilise the bone, and this will delay or prevent healing (Lovell 1997, 146). A relatively common complication of fractures is osteoarthritis. Osteoarthritis can be caused by joint fractures, or by abnormal biomechanical stress placed on the limb following a fracture. For example, the un-injured limb can be susceptible to osteoarthritis when it has to bear most of the body weight during the period when the injured limb is not used (Lovell 1997, 147). To distinguish between traumatically induced osteoarthritis and age-related osteoarthritis, two criteria are used: the presence of a fracture, and the absence of bilateral symmetry in the nature and degree of osteoarthritis (Ortner 2003, 157).

## Problems in studying fractures

Palaeopathologists can encounter several problems when studying fractures in archaeological material. First, the prevalence of fractures based on archaeological samples will always underestimate the true prevalence in past populations. Fractures in immature specimens may heal and remodel so completely that a fracture will not be recognised (Ortner 2003, 136); thus, fractures in non-adults will be underrepresented. Stress fractures are very hard to detect when healed, so they will also be underrepresented in archaeological samples. A second problem is that it is very difficult, and sometimes impossible, to distinguish between accidental fractures and fractures resulting from violence (Ortner 2003, 136). In order to make this distinction, it is necessary to understand the nature of the force causing the fracture. It is also difficult to distinguish between fractures that occurred just before death, and post-mortem fractures. Finally, in animal bone assemblages, we are usually dealing with fragments of individual bones and not complete skeletons. Consequently, complications of fractures may not be discernible since they may occur in other bones beside the fractured specimen. It also makes it difficult to identify animal abuse, since we cannot easily assess the distribution of fractures across individual skeletons (a key indicator of animal abuse; Teegen 2005), or the exact numbers of animals abused.

## Possibilities of studying fractures

Despite these problems, it is still worthwhile to study fractures. The prevalence and location of fractures in the skeleton are culturally influenced (Ortner 2003, 136), both in humans and in other animals. Domestic mammals have different functions in different societies, and some of these functions may predispose animals to fractures. Moreover, husbandry techniques can play an important role in fracture prevalence. Baker and Brothwell (1980, 91) offer the following research questions, specifically for palaeopathology in animals:

- is there a change in the frequency of fractures between time periods?
- is there a difference in the distribution of fractures for different species?

Additional questions that the analysis of fractures can also be used to explore include:

- what can fracture frequencies tell us about human-animal interaction, husbandry methods and animal function?
- does evidence exist for fracture treatment and what does this tell us about the value attributed to animals?

It is clear that in order to answer these questions more published data is required; the evidence presented below serves to provide such a contribution.

## Fractures from Tiel-Passewaaij

For this paper, 19 fractured mammal bones were studied. Two additional fractures were identified from the site, a horse (*Equus caballus* L., 1758) rib from the cremation cemetery in Tiel-Passewaaij and a chicken (*Gallus gallus* L., 1758) tibiotarsus; however, these were not considered for this study. The rib fracture was discarded because the animal bones from the cemetery are not comparable with the animal bones from the two settlements since many of the former have been cremated. The tibiotarsus was omitted because this paper focuses on mammals.

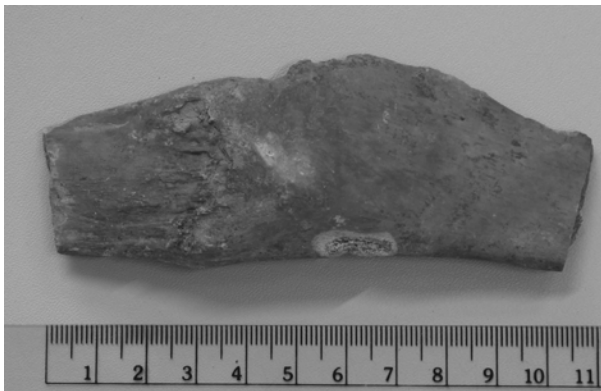
Tab. 6.1 provides a summary of the fracture evidence from Tiel-Passewaaij. All of the fractures were found in domestic mammals, they were all acute – no stress or pathological fractures were recognised – and no evidence for therapeutic intervention was apparent. The majority of fractures were found in dogs, and the most frequently fractured bones were ribs. Most rib fractures heal without any complications, because the bones are held rigidly in place. However, if rib fractures are caused by a massive injury, fragments can be displaced and penetrate the pleura, lungs or heart (Aufderheide and Rodríguez-Martín 1998, 25). Prior to the advent of modern veterinary care, this would usually have resulted in the death of the animal. However, the likelihood of distinguishing such unhealed ante-mortem fractures is small. Not all rib fractures will be discussed below; however, all non-rib fractures are described and illustrated.

Location	Cattle	Horse	Pig	Dog	Total
Mandible	1	-	-	1	2
Ribs	2	1	1	3	7
Vertebrae	-	-	-	1	1
Humerus	-	-	-	1	1
Radius	-	-	-	2	2
Ulna	-	-	-	1	1
Tibia	-	-	-	1	1
Fibula	-	-	-	1	1
Metapodials	-	1	1	1	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>12</b>	<b>19</b>

**Table 6.1:** location of fractures in the animal bones from Tiel-Passewaaij.



**Figure 6.2:** rib fracture in cattle; pleural view (TL 147-165).



**Figure 6.3:** rib fracture in cattle; external view (TL 147-165).

Figs. 6.2 and 6.3 illustrate the united fracture of a cattle (*Bos taurus* L., 1758) rib. The callus in this specimen is irregular and the surface is rough on the external side but smoother on the pleural side. The fracture line is clearly visible, both on the bone and on an x-ray (as a radiolucent line).

The fracture of a pig (*Sus scrofa* L., 1758) rib illustrated in Figs. 6.4 and 6.5 has occurred not long before death. The fracture is located in the proximal third of the bone and has not united. There is some callus formation that is rough and porous.



**Figure 6.4:** rib fracture in pig; pleural view (TLP OTW 36-295/24).

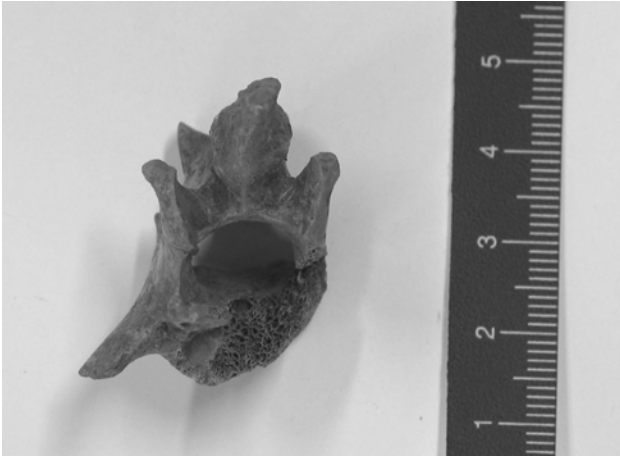


**Figure 6.5:** rib fracture in pig (TLP OTW 36-295/24).

A lumbar vertebra of a dog (*Canis familiaris* L., 1758) exhibited a fracture of the spinous process (Fig. 6.6), which healed with thick callus formation and had subsequently remodelled.

The right cattle mandible depicted in Figs. 6.7 and 6.8 reveals a fracture of the vertical ramus. Callus has formed and the two ends of the bone are in the process of fusing. The mandible has broken post-mortem at the fracture site. The callus is thick and part of the surface is porous, suggesting the fracture was relatively recent. The fact that the second molar has not erupted indicates the animal was not very old.

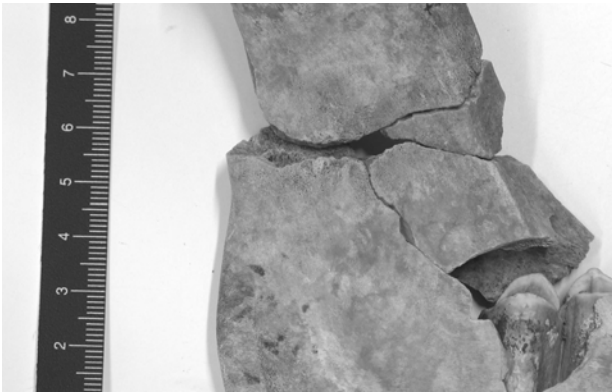
The left dog mandible in Fig. 6.9 has a fracture across the horizontal ramus, just in front of the first molar. The fracture has not yet fused and thus occurred shortly before death. Unfortunately, only the posterior end of the fracture site is present. There is some callus formation, which is porous and not remodelled. The mandible is part of an almost complete skeleton of an immature dog. The dog's age was estimated at 10-12 months according to Silver (1969, table A).



**Figure 6.6:** fracture in the spinous process of a dog lumbar vertebra; cranial view (TL 122-90).



**Figure 6.9:** fracture in a dog mandible; medial view (TL 197-57).



**Figure 6.7:** fracture in a cattle mandible; lateral view (TL 165-140).



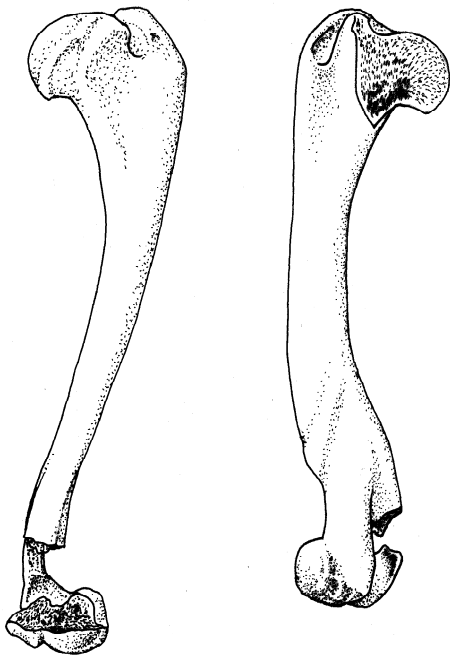
**Figure 6.8:** fracture in a cattle mandible (TL 165-140).



**Figure 6.10:** fracture in a dog humerus, medial view (TLP OTW 36-252).

Figs. 6.10-6.12 demonstrate a well-healed fracture of a right dog humerus. The fracture is located in the distal third of the diaphysis and appears to be oblique as evidenced in the x-ray as a radiolucent line. The two fractured ends of the bone have overlapped, leading to foreshortening; however, they have fused together and the callus has remodelled into normal bone, indicating that the dog survived long after it was injured. The greatest length of the humerus was measured, as well as that of the opposite, unaffected bone. The fractured humerus has a length of 151 mm, whereas the greatest length of the unaffected left humerus is 167 mm.





**Figure 6.11:** fractured dog humerus (right) united with shortening compared with the normal left humerus from the same individual (TLP OTW 36-252). Drawing by Mikko Kriek, ACVU-HBS.

A double fracture of a right dog radius and ulna was found in a complete dog skeleton (Figs. 6.13 and 6.14). The bone ends have fused with considerable distortion, uniting the radius and ulna together. The fracture line in the radius appears to be oblique in the x-ray. The two fragments are misaligned, both antero-posteriorly and medio-laterally. The distal fragment is angulated to the lateral and posterior side. The medio-lateral view in the x-ray shows that the two ends do not touch at all. A large callus has formed around the bone ends, fusing the two parts. The greatest length of the radius could not be measured, because the distal epiphysis is missing. The antero-posterior view of the ulna in the x-ray shows that the two fragments are closely aligned, but that the apposition is poor, although it is not possible to determine the type of fracture. The greatest length of the fractured ulna is 208 mm, while that of the unaffected left ulna is 215 mm. One of the left carpal bones (*os carpi radiale et intermedium*) exhibits eburnation, one of the signs of osteoarthritis. Considering the distortion of the radius and ulna, it is not surprising that the fracture had affected the joints below. This dog is a male adult individual with an average withers height of 60 cm (Harcourt 1974). Apart from the double fracture of the radius and ulna, the animal also suffered a rib fracture.

Fig. 6.15 illustrates a second radius fracture in a dog, occurring in the distal third of the bone. The fracture is well-healed: the callus has been remodelled and the marrow cavity had been restored. The bone is not complete, so no comment can be made regarding the extent of shortening or angulation.

A fracture of the right tibia and fibula occurred in the



**Figure 6.12:** x-ray of a fractured dog humerus, lateral view (TLP OTW 36-252).

same dog that suffered the humerus fracture (Figs. 6.16 and 6.17). Because the bone was broken during excavation, and the other half was lost, the fracture type is not determinable. The fibula exhibits curvature, so it can be assumed that the realignment was not perfect and it is likely that the fractured tibia was shorter than the unaffected tibia. The tibia was fractured in the distal third of the diaphysis, and had fused, but with considerable distortion. A large callus has formed, and is well remodelled, although the marrow cavity had not reformed prior to the death of the animal. It is not possible to say whether the two fractures occurred at the same time. The ossification of a muscle attachment on the right femur of the same animal was also observed (Fig. 6.18). It is possible that this occurred because of the additional strain resulting from the animal holding its leg up during the healing process, or as a result of foreshortening.

While no fracture line was visible on x-rays of two right metatarsals (IV+V) of a dog, the presence of callus and the fusion of the two bones suggest the presence of an old fracture (Fig. 6.19). The bone has not completely remodelled and the surface is quite rough. It is possible that both bones were fractured simultaneously, around the mid-section of the diaphysis. The correct alignment can be explained by the presence of the other metatarsals, which would have acted as natural splints for the



**Figure 6.13:** healed fracture in a dog radius and ulna; medial view (TL 165.150).



**Figure 6.14:** x-ray of a healed fracture in a dog radius and ulna; medial view (TL 165.150).

fractured bones. Well-healed metapodials without shortening or misalignment are commonly found in dogs (Udrescu and Van Neer 2005).

The right metacarpal of a horse is probably fractured (Fig. 6.20). An x-ray was taken, in which the fracture appears visible as a radiolucent line. The location of the fracture is close to the proximal end of the bone. The fracture has healed, fusing the second metacarpal to the third. In this case, the second metacarpal has acted as a natural splint (Udrescu and Van Neer 2005).

Finally, a right fifth metatarsus from a pig demonstrates a well-healed fracture (Fig. 6.21). A thick callus has formed around the fracture and has partly remodelled. The marrow cavity had not been restored before death.

## Discussion

If we compare the number of fractures with the total number of bone fragments, we can calculate prevalence for all domestic mammals, and for each separate species (Tab. 6.2).

The overall prevalence of fractures in the faunal assemblage from Tiel-Passewaaij is 0.14% for all domestic mammals. For dogs, the fracture prevalence is 0.93%, while for the other domestic species, prevalence



**Figure 6.15:** fracture in a dog radius; anterior view (TL 148-96).



**Figure 6.16:** fracture in a dog tibia and fibula; anterior view (TLP OTW 36-252).



**Figure 6.18:** ossification in a dog femur; lateral view (TLP OTW 36-252).



**Figure 6.17:** fracture in a dog tibia and fibula; posterior view (TLP OTW 36-252).



**Figure 6.19:** fractured dog metatarsals (TL 165-161).



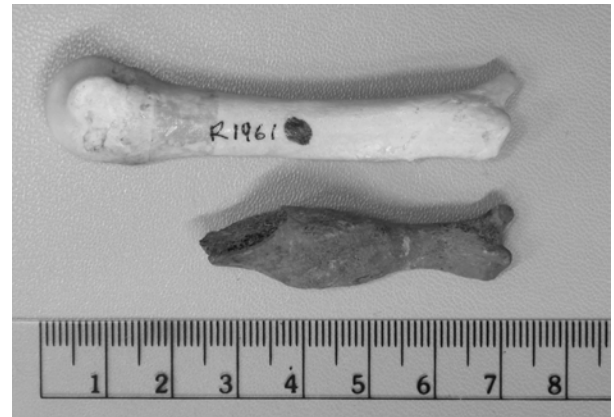
**Figure 6.20:** a probable fracture in a second horse metatarsal; lateral view (TL 179-171).

ranges from 0% for sheep (*Ovis aries* L., 1758) to 0.14% for pig. The prevalence for all domestic mammals together is a much higher number than the ‘normal’ frequency of 0.04% noted by Baker and Brothwell (1980, 91). The latter figure was obtained by combining results from their own survey with data published by Siegel (1976).

Why then is the fracture prevalence for Tiel-Passewaaij higher than that mentioned by Baker and Brothwell? The material included in the latter sample was from different periods; one possible conclusion therefore, is that fractures were more common in the Roman period.

Clearly, however, more systematic publication of fracture prevalence for sites from different periods is needed to answer this question (a point also emphasised by Thomas and Mainland 2005). What is a more interesting question at this moment is why the fracture prevalence is so much higher for dogs at Tiel-Passewaaij, compared to other domestic mammals.

One explanation is that fracture frequency is related to body size. Healed long bone fractures in cattle and horses are rare with only metapodial fracture known from the literature (Udrescu and Van Neer 2005). Fractures of the other long bones heal poorly and animals suffering long bone fractures in antiquity may have been slaughtered (as they often are today), in which case we would not find any evidence for their occurrence. Body size may explain the low fracture prevalence for horse and cattle, but if this was an important factor in fracture prevalence, we would expect to find similar frequencies in dogs, pigs and sheep. However, we have already seen that fracture prevalence is much higher in dogs than in other medium-sized mammals.



**Figure 6.21:** fracture in a pig fifth metatarsal, compared to a normal specimen (TL 170-92).

Dogs may be more susceptible to fractures than other mammals, because they live in closer proximity to humans. If this is indeed the case then we must consider maltreatment as a cause for the fractures. Teegen (2005) has discussed this issue, through the consideration of rib and vertebral fractures from medieval cities in Northern Germany. The dog bones in this sample showed a high frequency of rib and vertebral fractures.

Species	Fractures	Total NISP	% fractures
Cattle	3	5760	0.05
Horse	2	1950	0.1
Pig	2	1444	0.14
Sheep	0	2927	0
Dog	12	1277	0.93
<b>Total</b>	<b>19</b>	<b>13,358</b>	<b>0.14</b>

**Table 6.2:** prevalence of fractured bones by species at Tiel-Passewaaij.

One of the diagnostic traits for deducting abuse is the occurrence of multiple fractures in different stages of healing and Teegen found evidence for this in some partial skeletons. Other explanations for the fractures are mentioned: kicks from large animals, bite wounds from other dogs, and pathological fractures. However, Teegen (2005) believes that the presence of both rib and vertebral fractures in different stages of healing in individual animals is more suggestive of abuse by humans. Teegen and Wussow (2000) also discovered rib and vertebral fractures in nineteenth and early twentieth-century pigs and sheep, suggestive of kicking and beating by humans, and this interpretation is supported by documentary evidence for the use of pitchforks in handling these animals.

At Tiel-Passewaaij, both rib fractures and one fracture of the spinous process are present, but not in significant numbers. Multiple fractures in individuals are present: one dog suffered fractures of the humerus and tibia/ fibula, but because both fractures are well-healed, it is not possible to determine whether the injuries occurred simultaneously.

Another dog suffered a double fracture of the radius/ulna and a fractured rib, although again it is not possible to determine whether these fractures were the result of one or two traumatic events. In another dog, two ribs were fractured, probably at the same time.



**Figure 6.22:** burial of a dog skeleton and a horse skull at Tiel-Passewaaij.

If we accept the hypothesis that fractures in dogs are the result of maltreatment by humans, we must consider why dogs were maltreated, and other domestic mammals were not. The spatial proximity of dogs to humans may provide one explanation. In this case, dogs were not intentionally treated worse than other animals; rather, the numbers of interactions (and opportunities for abuse) was greater. Another explanation is that dogs were not seen as valuable animals, and that they did not play an important role in society. Although we cannot discard this hypothesis, the careful burial of some dogs seems to contradict the idea of dogs being regarded in purely functional terms. The dog that suffered both a radius/ulna fracture and a rib fracture, for example, was carefully buried with a horse skull, in a ditch that surrounded a Late Roman part of the settlement (Fig. 6.22). Another dog was buried with the partial skeleton of a red deer, two dogs were buried on top of large pottery sherds (Fig. 6.23), and two more were buried in ditches surrounding houses. All these animals were buried with care and in a very deliberate manner. The location of the burials and the associated finds are not random. Dogs feature

prominently in the ‘special animal deposits’ that have been identified at Tiel-Passewaaij. Clearly, the roles dogs fulfilled were not just functional but also symbolic. However, as Thomas (2005) emphasises, the way in which animals are buried only tells us about their treatment in death, and not in life. Dogs may have been useful animals in life, and used in a symbolic manner after death, but this may not have saved them from maltreatment.

Another possibility is that the fractures in dogs are related to injuries sustained during work. Both hunting and herding can be dangerous activities, involving large, potentially aggressive animals. The association of a dog skeleton and a partial red deer skeleton is clearly suggestive of the use of dogs for hunting; however, wild mammals are rare at Tiel-Passewaaij, so hunting was probably not a very common activity. Therefore, it is unlikely that hunting injuries would be an important cause of fractures in dogs. Livestock, on the other hand, played a vital role in the rural economy and animals were probably traded with the Roman army or the city. Dogs could have been valuable companions, helping transport cattle to markets, for instance, or rounding up animals from the fields. This would predispose them to kicks from cattle and horses, which could easily result in fractures. Even the small dog with the broken mandible could have been a herding dog: nowadays, several breeds of small dogs still exist that were originally developed for herding cattle, such as the Welsh corgi, the Lancashire Heeler and the Swedish Vallhund.



**Figure 6.23:** burial of a dog on top of large pottery sherds at Tiel-Passewaaij.



A final possibility we must consider is intra-species aggression. Although fractures can, in theory, be a result of aggression between dogs, this does not seem to be plausible explanation in this case. Bite wounds in dogs are often directed at the head and shoulder region, rather than the extremities (Baranyiová *et al.* 2003, 58-59). Further-more, none of the fractures seem to be caused by puncture wounds.

## Conclusions

Currently, it appears that the high fracture prevalence for dogs in Roman Tiel-Passewaaij is either the result of maltreatment by humans or kicks from large animals. More research into the location of fractures in known herding dogs as well as known abused dogs could perhaps help identify the cause of the dog fractures in Tiel-Passewaaij (Thomas and Mainland 2005) and could tell us more about the function of dogs and human attitudes to them.

In addition to research into modern fracture rates, more work also needs to be done using archaeological material. Patterns of fractures need to be studied, and for this large samples of animal bones are needed. Fractures should be recorded and published systematically, preferably with illustrations. It is important not just to describe fractures in reports on animal bones, but also to publish prevalence rates of fractures for different species and different time periods. Only by gathering a large amount of data, will we be able to make any more meaningful conclusions in the future.

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